

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of

Rudolf HEINZ et al

Based on PCT/DE 01/01328

For: PIEZOELECTRIC ACTUATOR

**PRELIMINARY AMENDMENT**

Commissioner for Patents  
Washington, D.C. 22314

Sir:

Prior to examination, please amend the above-referenced application as follows:

**IN THE SPECIFICATION**

**Page 1**, between the title and paragraph [0001] insert the following:

[0000.2] CROSS-REFERENCE TO RELATED APPLICATIONS

[0000.4] This is a 35 U.S.C. 371 application of PCT/DE 01/01328, filed on April 5, 2001.

[0000.6] BACKGROUND OF THE INVENTION

replace paragraph [0001] with the following amended paragraph:

[0001] Field Of The Invention

replace paragraph [0002] with the following amended paragraph:

[0002] The invention relates to a piezoelectric actuator, for instance for actuating a mechanical component such as a valve or the like.

between paragraphs [0002] and [0003] insert the following:

[0002.5]      Brief Description Of The Prior Art

**Page 2**, replace paragraph [0004] with the following amended paragraph:

[0004] Such piezoelectric actuators can be provided for instance for driving switching valves in fuel injection systems of motor vehicles. In operation of the piezoelectric actuator, care must be taken in particular to assure that mechanical stresses in the layer construction not cause any problematic development of cracks in the region of the outer or connection electrodes. Since the inner electrodes, each contacted on one side, are integrated in comblike fashion with the layer structure, the successive electrodes in the direction of the layer structure must each be contacted on opposite sides in alternation.

replace paragraph [0005] with the following amended paragraph:

[0005] Upon an actuation of the piezoelectric actuator, that is, when a voltage is applied between the opposed inner electrodes in the layer structure, different mechanical forces occur in the region of the inner electrodes and in the region of the contacts on the outer electrodes, and these can cause mechanical stresses and hence cracks in the outer electrodes. The outer electrodes must then in turn be provided with connection electrodes, which as a rule must also withstand mechanical stresses.

**Page 3**, replace paragraph [0006] with the following amended paragraph:

[0006] SUMMARY OF THE INVENTION

replace paragraph [0007] with the following amended paragraph:

[0007] The piezoelectric actuator according to the invention, which can for instance be used to actuate a mechanical component, is advantageously embodied in such a way that at least one layer of the applicable outer electrode is constructed in network-or fabric-like fashion, distributed each over a respective side face, and is contacted at least at some points with the applicable inner electrodes. The network-or fabric-like outer electrodes are lengthened beyond the multilayer structure of piezoelectric layers in such a way that at the extensions, the delivery of the electrical voltage takes place via suitable terminals.

**Page 5**, replace paragraph [0013] with the following amended paragraph:

[0013] These and other characteristics of preferred refinements of the invention can be learned from the description and the drawings; the individual characteristics can each be realized on their own or multiple characteristics can be realized in the form of subsidiary combinations both in the embodiment of the invention and in other fields and can represent both advantageous and intrinsically patentable embodiments for which patent protection is here claimed.

**Page 6**, replace paragraph [0014] with the following amended paragraph:

[0014] BRIEF DESCRIPTION OF THE DRAWINGS

replace paragraph [0015] with the following amended paragraph:

[0015] Exemplary embodiments of the piezoelectric actuator of the invention will be explained in detail herein below, in conjunction with the drawings, in which:

replace paragraph [0016] with the following amended paragraph:

[0016] Fig. 1 is a section through a piezoelectric actuator with a multilayer structure of layers of piezoceramic and inner electrodes, as well as a netlike outer electrode lengthened by a foot part;

**Page 8**, replace paragraph [0025] with the following amended paragraph:

[0025] DESCRIPTION OF THE PREFERRED EMBODIMENTS

**Page 10**, after paragraph [0030] insert the following new paragraph:

[0031] The foregoing relates to preferred exemplary embodiments of the invention, it being understood that other variants and embodiments thereof are possible within the spirit and scope of the invention, the latter being defined by the appended claims.

**Page 11**, line 1, delete "Claims" and insert --"We Claim"--.

## IN THE CLAIMS

Please cancel claims 1-10 and add new claims 11-30.

11. A piezoelectric actuator comprising

- a multilayer structure of piezoelectric layers and inner electrodes (2, 3) disposed between the piezoelectric layers;
- an alternate-side lateral contacting of the inner electrodes (2, 3) via outer electrodes (4, 5), via which an electrical voltage can be delivered; wherein
- the outer electrodes (4, 5) each being in the form of a network or fabric applied and distributed over one side face, and contacted at least at some points to the respective inner electrodes (2, 3), said outer electrodes (4,5) including a stretchable region between said contact points;
- the network-or fabric-like outer electrodes (4, 5) each being lengthened beyond the multilayer structure of piezoelectric layers in such a way that the delivery of the electrical voltage is effected at the extensions (8, 9).

12. The piezoelectric actuator of claim 11, wherein

- the extensions (8, 9) are guided, electrically insulated (10), by a foot part (6) of the piezoelectric actuator (1), to which part the multilayer structure of piezoelectric layers is secured.

13. The piezoelectric actuator of claim 12, wherein

- the extensions (8, 9) are held in a potting composition (12), which is introduced into a recess (11) of the foot part (6).

14. The piezoelectric actuator of claim 13, wherein
  - the potting composition (12) is surrounded by a shaped part (13).
15. The piezoelectric actuator of claim 11, wherein
  - the outer electrodes (4, 5) are tapered in the region of the extensions (8,9).
16. The piezoelectric actuator of claim 13, wherein
  - the outer electrodes (4, 5) are tapered in the region of the extensions (8,9).
17. The piezoelectric actuator of claim 11, wherein
  - the outer electrodes (4, 5) are folded in the region of the extensions (8, 9).
18. The piezoelectric actuator of claim 13, wherein
  - the outer electrodes (4, 5) are folded in the region of the extensions (8, 9).
19. The piezoelectric actuator of 15, wherein
  - the outer electrodes (4, 5) are folded in the region of the extensions (8, 9).
20. The piezoelectric actuator of claim 11, wherein
  - the outer electrodes (4, 5) are coiled in the region of the extensions (8, 9).
21. The piezoelectric actuator of claim 12, wherein
  - the outer electrodes (4, 5) are coiled in the region of the extensions (8, 9).

22. The piezoelectric actuator of claim 13, wherein

- the outer electrodes (4, 5) are coiled in the region of the extensions (8, 9).

23. The piezoelectric actuator of claim 14, wherein

- the outer electrodes (4, 5) are coiled in the region of the extensions (8, 9).

24. The piezoelectric actuator of claim 11, wherein

- the network-or fabric-like outer electrodes (4, 5) comprise crossed wires (14, 15)

laid at an incline of  $45^\circ$ .

25. The piezoelectric actuator of claim 13, wherein

- the network-or fabric-like outer electrodes (4, 5) comprise crossed wires (14, 15)

laid at an incline of  $45^\circ$ .

26. The piezoelectric actuator of claim 15, wherein

- the network-or fabric-like outer electrodes (4, 5) comprise crossed wires (14, 15)

laid at an incline of  $45^\circ$ .

27. The piezoelectric actuator of claim 11, wherein

- the network-or fabric-like outer electrodes (4, 5) comprise crossed wires (14, 15)

laid horizontally and vertically.

28. The piezoelectric actuator of claim 13, wherein

- the network-or fabric-like outer electrodes (4, 5) comprise crossed wires (14, 15)

laid horizontally and vertically.

29. The piezoelectric actuator of claim 24, wherein

- the wires (14, 15) are contacted to one another by being copper-or tin-plated to one another.

30. The piezoelectric actuator of claim 27, wherein

- the wires (14, 15) are contacted to one another by being copper-or tin-plated to one another.



**IN THE ABSTRACT**

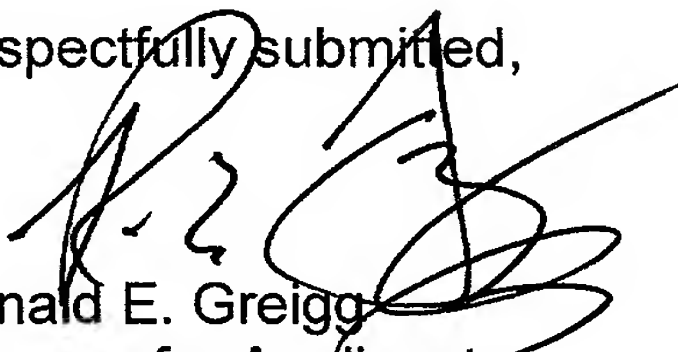
Please substitute the attached Abstract of the Disclosure for the abstract as originally filed.

**REMARKS**

The above amendments are being made to place the application in better condition for examination.

Entry of the amendment is respectfully solicited.

Respectfully submitted,

  
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## ABSTRACT OF THE DISCLOSURE

A piezoelectric actuator, for instance for actuating a mechanical component, is proposed that has a multilayer structure of piezoelectric layers and disposed between them inner electrodes and an alternate-side lateral contacting of the inner electrodes via outer electrodes. The outer electrodes are applied in network-or fabric-like fashion, each distributed over one side face, and are contacted at least at some points to the respective inner electrodes. The outer electrodes are lengthened past the multilayer structure of piezoelectric layers in such a way that the delivery of the electrical voltage takes place at the extensions.

## VERSIONS WITH MARKINGS TO SHOW CHANGES MADE

### IN THE SPECIFICATION

**Page 1**, between the title and paragraph [0001]:

[0000.2]     CROSS-REFERENCE TO RELATED APPLICATIONS

[0000.4]     This is a 35 U.S.C. 371 application of PCT/DE 01/01328, filed on April 5, 2001.

[0000.6]     BACKGROUND OF THE INVENTION

paragraph [0001]:

[0001]     [Prior Art] Field Of The Invention

paragraph [0002]:

[0002]     The invention relates to a piezoelectric actuator, for instance for actuating a mechanical component such as a valve or the like[, as generically defined by the characteristics of the preamble to the main claim].

between paragraphs [0002] and [0003]:

[0002.5]     Brief Description Of The Prior Art

**Page 2**, paragraph [0004]:

[0004]     Such piezoelectric actuators can be provided for instance for driving switching valves in fuel injection systems of motor vehicles. In operation of the piezoelectric actuator, care must be taken in particular to assure that mechanical stresses in the layer construction not cause any problematic development of cracks in the region of the outer or connection electrodes. Since the inner electrodes, each contacted on one side, are integrated in comblike fashion with the layer structure, the successive electrodes in the direction of the layer structure must each be contacted on opposite sides in alternation.

paragraph [0005]:

[0005] Upon an actuation of the piezoelectric actuator, that is, when a voltage is applied between the opposed inner electrodes in the layer structure, different mechanical forces occur in the region of the inner electrodes and in the region of the [contactings] contacts on the outer electrodes, and these can cause mechanical stresses and hence cracks in the outer electrodes. The outer electrodes must then in turn be provided with connection electrodes, which as a rule must also withstand mechanical stresses.

**Page 3, paragraph [0006]:**

[0006] [Advantages of the Invention] SUMMARY OF THE INVENTION

paragraph [0007]:

[0007] The piezoelectric actuator [described at the outset] according to the invention, which can for instance be used to actuate a mechanical component, is advantageously embodied in such a way that at least one layer of the applicable outer electrode is constructed in network-or fabric-like fashion, distributed each over a respective side face, and is contacted at least at some points [to] with the applicable inner electrodes. The network-or fabric-like outer electrodes are lengthened beyond the multilayer structure of piezoelectric layers in such a way that at the extensions, the delivery of the electrical voltage takes place via suitable terminals.

**Page 5, paragraph [0013]:**

[0013] These and other characteristics of preferred refinements of the invention can be learned [not only from the claims but also] from the description and the drawings; the individual characteristics can each be realized on their own or multiple characteristics can be realized in the form of subsidiary combinations both in the embodiment of the invention and in other fields and can represent both advantageous and intrinsically patentable embodiments for which patent protection is here claimed.

**Page 6, paragraph [0014]:**

[0014] [Drawing] BRIEF DESCRIPTION OF THE DRAWINGS

paragraph [0015]:

[0015] Exemplary embodiments of the piezoelectric actuator of the invention will be explained in detail herein below, in conjunction with the [drawing. Shown are] drawings, in which:

paragraph [0016]:

[0016] Fig. 1[,] is a section through a piezoelectric actuator with a multilayer structure of layers of piezoceramic and inner electrodes, as well as a netlike outer electrode lengthened by a foot part;

**Page 8, paragraph [0025]:**

[0025] [Description of the Exemplary Embodiments] DESCRIPTION OF THE  
PREFERRED EMBODIMENTS

**Page 10, after paragraph [0030]:**

[0031] The foregoing relates to preferred exemplary embodiments of the invention, it  
being understood that other variants and embodiments thereof are possible within the  
spirit and scope of the invention, the latter being defined by the appended claims.

[Abstract] **ABSTRACT OF THE DISCLOSURE**

A piezoelectric actuator, for instance for actuating a mechanical component, is proposed that has a multilayer structure of piezoelectric layers and disposed between them inner electrodes [(2, 3)] and an alternate-side lateral contacting of the inner electrodes [(2, 3)] via outer electrodes [(4, 5)]. The outer electrodes [(4, 5)] are applied in network- or fabric-like fashion, each distributed over one side face, and are contacted at least at some points to the respective inner electrodes [(2, 3)]. The outer electrodes [(4, 5)] are lengthened past the multilayer structure of piezoelectric layers in such a way that the delivery of the electrical voltage takes place at the extensions [(8, 9)].

[(Fig. 1)]